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EPIDEMIOLOGICAL STUDY OF AN OUTBREAK OF TYPHO'D FEVER OCCURRING IN COVINGTON AND NEWPORT, KENTUCKY, AND ADJACENT TERRITORY

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EPIDEMIOLOGICAL STUDY OF AN OUTBREAK OF TYPHOID FEVER OCCURRING IN COVINGTON AND NEWPORT, KENTUCKY, AND ADJACENT TERRITORY.

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(April 23, 1923).

Epidemiological Study of an outbreak of Typhoid Fever occurring in Covington and Newport, Kentucky, and adjacent territory.

(April 23, 1923).

At the request of Dr. A. T. McCormack, State Health Officer of Kentucky, the Surgeon General of the United States Public Health Service instructed Sanitary Engineer J. K. Hoskins to render such assistance to the Kentucky State Board of Health as might be needed to make a study of the epidemic of typhoid fever occurring in the cities of Covington, Newport and adjacent territory. In compliance with these instructions a comprehensive survey of existing conditions was made by the writers in order to determine the factor or factors responsible for the outbreak. The results of these investigations are presented herewith, together with conclusions formed as a result of the findings, as well as recommendations for the prevention of further infection from the source found to be responsible for the present epidemic.

In order that immediate action might be taken on urgently necessary measures, a brief statement of our conclusions and recommendations for temporary improvements has been submitted to the State Health Officer, copies of which were supplied to the health officials of the cities of Covington and Newport and to the health officers of Campbell and Kenton Counties, Kentucky.

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General Description of Area Affected.

The cities of Newport and Covington are located on the south bank of the Ohio River, directly opposite to the city of Cincinnati. The Licking River, a tributary of the Ohio, forms a dividing line between the two cities, Newport being immediately east and Covington west of this stream. Other smaller municipalities, Bellevue, Dayton and Fort Thomas, adjoin Newport on the east and south, while Ludlow lies immediately west of Covington along the Ohio River. Both Covington and Newport are built on the sloping river plain of the Ohio and extend back to the foot hills. Bellevue, Dayton and Fort Thomas are generally on the higher ground. All of the drainage is to the Ohio and Licking rivers, or to smaller branches or runs that drain to these streams.

All of the municipalities are mostly residential, many of the citizens being employed in Cincinnati industries. The total population according to the 1910 and 1920 Census is divided as follows:

Population of Newport-Covington Metropolitan Area.

Municipality	1910	1920	Estimated Jan.1,1923.
Covington	53,270	57,121	60,142
Newport	30,309	29,317	29,013
Bellevue	6,683	7,339	7,595
Dayton	6,979	7,646	7,852
Clifton	---	2,065	2,065
Ludlow	4,163	4,582	4,711
West Covington		1,800	--- *
Fort Thomas		5,038	5,038
Totals		114,938	116,406

* Now part of Covington.

Organization of Municipal Government.

Both Covington and Newport have the Commission form of government. The commission in each case is composed of four members, elected every two years, and a mayor, who acts as executive of the governing body, elected for a four-year term. The Commissioners are solely responsible for the policies and functioning of the municipally-owned public utilities and all the municipal departments. The city health department is in each case responsible to the Commission for the execution of duties assigned to that department by existing law.

Appropriations of funds for carrying on municipal health activities are alloted by the City Commissioners. In the same way the conduct and operation of the water works departments is under the supervision of the Commission. There can there-

fore be no evasion of responsibility on the part of the Commissioners for improper conduct of any departments of the respective city governments. If impure water, contaminated milk, or other harmful foods, are being supplied to the citizens, it is the evident duty and responsibility of these executives to eliminate such conditions. Ignorance of the existence of such faulty service is no sufficient excuse, for they have the power, and in them is vested the responsibility, to protect the health and well-being of all the inhabitants of their respective municipalities. It is their duty to provide the requisite facilities to keep themselves informed of the condition and purity of the water supplied to the people and to take adequate measures to prevent the outbreak of such epidemics as the present one. If they find it impossible to provide safe water supplies with the funds voted by the electors, they should endeavor to make this condition widely known and place the responsibility directly on the citizenship.

Municipal Health Organization.

The Covington health activities are in charge of a part-time health officer responsible to the Commissioner of Public Safety. The force consists of one meat and milk inspector, one sanitary inspector and one stenographer, all full-time employees. Offices and a laboratory, not completely equipped, are provided in the municipal building.

The Newport health department consists of a part-time health officer, assisted by one milk inspector and one sanitary inspector, both serving full-time. Two public health nurses, whose salaries are paid by the Health and Welfare League, have their headquarters with the City Health Department and cooperate closely with the local health authorities.

Public Water Supplies.

The source of the public water supply of Covington, Newport and adjacent municipalities is the Ohio River, none of which is properly purified before being delivered to the distribution systems.

Newport pumps water from the Ohio River at a point above the city of Cincinnati, to the upper of two reservoirs located on the higher ground of Fort Thomas, where small amounts of sulphate of iron and lime are added to assist coagulation and precipitation of the suspended matter. The capacity of the reservoir system, 60 million gallons, normally permits from 15 to 20 days' storage, from which the water is fed to the distribution system by gravity and supplies Newport, Dayton, Clifton and a section of Bellevue. No provision is made for systematic analyses of the supply.

Covington also pumps water from the Ohio River a short distance above the Newport pumping station and above the mouth of the Miami River. Water is delivered to one of two settling

reservoirs located on the high ground of Ft. Thomas, of 41 and 38 million gallons respectively, where it is allowed to settle. The settled water is drawn to a third or distributing reservoir of 32 million gallons capacity, from which it is fed into the distribution system. A combined maximum storage of approximately 22 days is provided in these reservoirs. Chlorine is added to the water as 't passes through the large trunk main from the distributing reservoir on its way to the city. This water is supplied to Covington, Ludlow, Fort Thomas, the Army Post at Ft. Thomas, and to part of Bellevue. Normally the Army Post pumps water direct from the distributing reservoir, at which point also chlorine is added to this part of the supply. The Ft. Thomas municipal supply is pumped to an elevated tank, the pump taking its suction from the 30" Covington city main leading from the distributing reservoir at a point approximately 8 feet below the point where chlorine is added.

An emergency connection with the mains of the Newport system exists whereby either city may supply the other in times of need.

The public water supplies are used by the greater part of the population of all these municipalities. The normal daily consumption is approximately 8,000,000 gallons.

Private Water Supplies.

There are relatively few private water supplies in these cities, very few persons depending on wells or cisterns. In what was formerly West Covington, now a part of the corporation of Covington, a survey made in 1915 by the Public Health Service indicated that practically every house had a cistern and, where the city water was not available, these cisterns were used for drinking. Presumably many of these cisterns are still in use in West Covington.

Sewage Disposal.

Covington is fairly well sewered with a combined system of sewers discharging through various outlets to the Licking and Ohio rivers. Newport is practically completely sewered, with a combined system of sewers, but many of the residences are not connected. Surveys made of all the cities in 1915 by the U. S. Public Health Service indicated the status of sewage disposal at that time to be as follows:

Method of Sewage Disposal in 1915.

	Number of Sewer Connections	Per Cent of Population Using: Sewers	Cess-pools	Pit Privies
Covington	6,375	66	2.0	32.0
Newport	4,173	65	1.5	33.5
Dayton	530	38	---	62.0
Ludlow	888	88	---	12.0
Bellevue	1,082	67	---	33.0
Clifton	-----	--	80.0	20.0
West Covington (Now part of Covington)	-----	10	---	90.0
Ft. Thomas	48	5	80.0	15.0

At present it is estimated that 75 per cent of the population of both Covington and Newport are connected to the public sewers.

There are in Covington approximately 1,800 privies, mostly of the pit type. No estimate of the number in Newport is available, though a considerable number exist in all sections of the city. Connections to sewers where available are not enforced in either Covington or Newport.

Prevalence of Typhoid Fever.

An examination of records of deaths from typhoid fever clearly shows that there has been an undue number of deaths from this disease in these towns. The records are as follows:

Deaths from Typhoid Fever, Covington and Newport, 1911 to 1923, inclusive.

	Covington	Newport	Total Deaths	Death Rate	Cincinnati Death Rate
1911	16	11	27	32.2	11.4
1912	8	7	15	17.8	7.8
1913	5	6	11	13.0	6.9
1914	10	5	15	17.7	6.4
1915	8	3	11	12.9	7.6
1916	9	4	13	15.2	3.3
1917	9	1	10	11.7	4.0
1918	8	4	12	14.0	4.8
1919	15	2	17	19.8	3.0
1920	3	4	7	8.1	3.2
1921	7	4	11	12.7	3.7
1923	2	0	2	2.3	3.2
Totals	100	51	151		

Compared with the Cincinnati typhoid death rate as given in the above table, and remembering that typhoid is a preventable disease, it is evident that there has been a needless waste of lives from typhoid in the Kentucky cities.

Epidemiology of the present outbreak of Typhoid Fever.

The present epidemic had its origin on January 2, at which time the first case in the series was reported. Cases then began to occur somewhat more frequently until the week of February 18 to 24, when five cases occurred. A sudden increase in reported cases then began, until a maximum point was reached on the week of March 4 to 10, inclusive, during which time 18 cases were reported. The distribution of cases by weeks is shown in the following table:

Dates of occurrence of cases of and deaths from Typhoid Fever - by weeks.

Week of:	Number of Cases Reported	Deaths
Jan. 1 - 6, incl.	2	
7 - 13 "	1	
14 - 20 "	4	
21 - 27	0	2
28 - Feb.3	3	
Feb. 4 - 10	3	2
11 - 17	2	
18 - 24	5	
25 - Mar.3	8	
Mar. 4 - 10	18	
11 - 17	17	1
18 - 24	16	2
25 - 31	9	1
Apr. 1 - 7	6	
8 - 14	2	1
Date not ascertained	3	
Total	99	9

The date of infection of cases has been particularly hard to determine in many instances, and the period of incubation seems to have been quite variable. Many cases visited gave histories of influenza attacks previous to the appearance of typhoid symptoms, and so the actual dates are not clearly defined in such cases. Indications are that the infective agent was present for a considerable time and that cases were infected covering a period of possibly several weeks.

A map on which the location of all cases has been plotted shows that the cases are well distributed throughout the areas of all of the cities with the exception that no cases have been reported from the part of Covington formerly known as West Covington. There seems to be no significant grouping with respect to any causative agent that would operate in any one particular section of the populated area. All portions of both cities are approximately equally affected in proportion to the density of population.

Only 5 cases among negroes have been reported, so that the majority of cases have been occurring among the white population. It is possible that some mild cases among colored have not been diagnosed and reported. There would appear however to be no particular responsible factor directly related to the sanitary surroundings of the families in which cases occur.

The cases have occurred most frequently in the age group ranging from 5 to 30 years, over 55 per cent being in this class. Males and females are approximately equally affected, as shown by the following table:

Distribution of cases by Age and Sex.

Age group	Male	Female	Total	Per Cent of Total Cases
0 - 4 years	1	0	1	1.0
5 - 9 "	7	7	14	14.1
10 - 14 "	10	12	22	22.3
15 - 19 "	7	12	19	19.2
20 - 24 "	7	3	10	10.1
25 - 29 "	4	4	8	8.1
30 - 34 "	5	4	9	9.1
35 - 39 "	3	4	7	7.1
40 - 44 "	0	0	0	0.0
45 - 49 "	0	0	0	0.0
50 - 54 "	1	2	3	3.0
55 - 59 "	1	0	1	1.0
60 - 64 "	1	0	1	1.0
Undetermined	1	3	4	4.0
	48	51	99	100.0

An attempt was made to secure from each case all information bearing on the possible sources from which infection could have been obtained, in order that the cause responsible for the epidemic might be determined as nearly as possible. For this purpose, each case was visited and certain data obtained for careful study. The source of milk supply was determined, and by grouping cases according to customers of various dairies, the following table is obtained:

Distribution of cases by Milk Supplies used.

Dairy	Number of Cases
Bergman Bros.	1
Bosse Sons	3
Crescent Dairy Co.	4
Deglow	1
Dusing	1
Feldman Milk & Cream Co.	10
French Bros.-Bauer	7
Henneken	4
Highland Dairy Co.	1
Kahn & Rehkamp	2
Moock	5
Newman	1
Schuman	1
Steffen	5
Summe & Ratterman	10
Sunny Crest	2
Tanner	1
Tri-State	8
Trenkamp	5
Private cow	3
Undetermined	13
No milk used	11
Total cases	99

It is evident that in this respect cases are well distributed and that the milk supply of no one or even any group of dairies is responsible for the epidemic. More cases are reported from homes where no milk or only canned milk is used, than from any one dairy.

Histories also show no grouping of cases about any food supply liable to carry the infection, such as ice cream or raw oysters, or from green vegetables such as lettuce, celery, etc. Few of the cases gave histories of attending any public dinners or restaurants where food could have been the causative agent.

Sewage Disposal.

Information relative to methods of sewage and excreta disposal at homes in which cases originated shows that approximately as many cases occurred in houses where inside sanitary flush closets are in use as in dwellings where outside pit privies are available. The greatest potential danger from pit or surface privies is transmission of disease by flies or by contamination of private well or cistern water supplies. Flies are not a factor at this time of year, and very few homes where cases occurred had wells or cisterns on their premises. Methods of excreta disposal can not therefore be held responsible for the present epidemic, although the large number of privies in Newport especially should be borne in mind as possible sources of later cases when flies become prevalent during the summer months.

Contact Cases.

An exceptionally small number of contact or secondary cases were found in the course of the detailed investigation. Four cases occurred in one family, two or three of which were doubtless caused by contact with the first case. In no other instance except one, did two cases occur at the same house, and at this place there was not sufficient time between onsets (one day) to definitely ascribe either case as secondary to the other. No other histories of contact with previous cases

were obtained, and in no other instances have secondary or subsequent cases been reported to date.

Investigation of the Public Water Supply.

A study of cases occurring indicates that every case investigated gave a history of having used either the Newport or Covington public water supply as a regular or occasional source for drinking purposes. No other factor investigated was common to even a small percentage of the cases, and the conclusion must therefore be drawn that the water supplied by these cities is responsible for the typhoid outbreak. Various other epidemiological features substantiate this conclusion, such as the wide distribution of cases throughout all parts of the area supplied with water, the gradual increase in the number of cases due to continued use of infected water, the sudden drop in number of cases reported when the water was treated with additional amounts of chlorine, the occurrence of a considerable number of cases of intestinal disturbances previous to the typhoid outbreak, and the heavy spring rains on the Ohio water shed that wash the surface pollution into the stream and quickly convey the infected material downstream.

With this evidence in hand it became necessary to consider carefully the condition of the public water supplies. The State Board of Health has made periodic examinations of these supplies since September, 1920. The results of these analyses

of the Covington supply are presented in the following table. It will be noted that in fifty per cent of the samples B.coli was present in 10 c.c. and in twenty-three per cent, B.coli was present in 1 c.c., indicating an unsafe water. The average number of bacteria growing at 37 degrees C. was 10,100.

Analyses made by the State Board of Health of the Water Supply of Covington, Ky. September 3,1920, to December 4,1922.

Date	Total Bacteria growing at 37 degrees C.	B.coli confirmed in: 10 c.c.	1 c.c.	0.1 c.c.	0.01 c.c.
Sept.3,1920	10,000	+	+	-	-
" 3	10,000	+	+	-	-
" 6	1,000	-	-	-	-
" 6	----	-	-	-	-
" 7	550	-	-	-	-
" 7	550	-	-	-	-
" 8	----	+	-	-	-
" 8	15,000	+	-	-	-
" 9	500	+	+	+	-
" 10	1,500	-	-	-	-
" 10	1,500	-	-	-	-
" 17	10,000	+	+	+	-
Dec. 2	3,000	+	-	-	-
" 6	1,000	-	-	-	-
" 8	900	+	+	-	-
" 8	950	+	-	-	-
" 13	3,000	+	+	-	-
" 13	2,500	+	-	-	-
" 15	120	+	+	+	-
" 15	100	+	-	-	-
Jan. 5,1921	100	-	-	-	-
" 5	100	-	-	-	-
" 12	1,500	+	+	-	-
" 12	900	+	-	-	-
" 31	200	+	-	-	-
Feb. 2	160	+	+	-	-
" 2	75	+	-	-	-
" 15	40	-	-	-	-
" 15	50	-	-	-	-

(Analyses by State Board of Health of Covington Water Supply, Continued).

Date	Total Bacteria growing at 36 degrees C.	B. coli confirmed in: 10 c.c.	1 c.c.	0.1 c.c.	0.01 c.c.
Feb. 21, 1921	110	+	-	-	-
21	30	+	+	+	-
23	18,200	-	-	-	-
Mar. 7	80	-	-	-	-
7	3,700	-	-	-	-
17	2,400	+	+	-	-
17	600	+	-	-	-
29	400	+	+	-	-
July 7	30,000	-	-	-	-
18	22,800	+	-	-	-
18	120,000	+	-	-	-
Aug. 15	8,400	-	-	-	-
15	30,000	+	-	-	-
Sept. 21	9,600	+	-	-	-
27	48,000	-	-	-	-
Oct. 11	2,400	-	-	-	-
26	2,400	-	-	-	-
Nov. 15	12,000	-	-	-	-
28	940	-	-	-	-
Dec. 28	250	-	-	-	-
Jan. 15, 1922	54,000	+	-	-	-
Mar. 13	48,000	+	+	-	-
29	200	+	+	-	-
Apr. 17	42,000	+	+	-	-
May 4	37,600	-	-	-	-
23	15,000	+	-	-	-
June 12	21,000	+	-	-	-
July 8	4,800	-	-	-	-
Aug. 16	2,000	-	-	-	-
31	----	-	-	-	-
Sept. 13	17	-	-	-	-
27	15,600	-	-	-	-
Oct. 17	6,000	-	-	-	-
Nov. 9	840	-	-	-	-
20	1,200	-	-	-	-
Dec. 4	360	-	-	-	-

Total samples examined		65
Number samples positive	B. coli in 10 c.c.	32
negative	" " " 10 "	33
positive	" " " 1 "	15
positive	" " " 0.1 "	4

Between January 1 and April 13, 1923, more frequent analyses have been made by the State Board. Of seventeen such samples examined, thirteen have shown B.coli present in 10 c.c., indicating that during this period the Covington water has not been safe for drinking purposes.

Newport has submitted less frequent samples for analysis, the results of which are given below. Of a total of twelve samples examined between January 17, 1921, and August 11, 1921, eight, or 67 per cent, showed the presence of B.coli in 10 c.c., and five, or 42 per cent, gave B.coli in 1 c.c., while the average number of bacteria present was 21,500.

Analyses made by the State Board of Health of the Water Supply of Newport, Ky.

Date	Total Bacteria 37.5 degrees C.	B.coli confirmed in: 10 c.c.	1 c.c.	0.1 c.c.	0.01 c.c.
Jan.17,1921	1,600	+	+	-	-
17	1,100	+	+	-	-
Feb.17	200	-	-	-	-
17	900	+	+	+	-
17	7,600	+	-	-	-
Mar. 5	1,700	-	-	-	-
5	135	+	-	-	-
5	1,200	+	-	-	-
July 27	18,000	+	+	-	-
27	16,000	+	+	-	-
Aug. 11	66,000	-	-	-	-
11	144,000	-	-	-	-

Total samples		12
negative		4
positive in	10 c.c.	8
positive	1 "	5
positive	0.1 "	1

During the present year one sample on March 12 showed B.coli present. Of four samples examined at the laboratory of the Kentucky Agricultural Experiment Station, March 15, three were shown to be polluted.

Since the outbreak of the present epidemic a number of samples of water from the various supplies have been analyzed by the laboratory of the United States Public Health Service in Cincinnati. The results of these analyses confirm those of the State Board of Health and point to the fact that these supplies are dangerously polluted.

Analyses of Covington Water Supply

made by

U. S. Public Health Service.

Sample No.	Date 1923	Source from tap at:	Turbidity	Bacteria per c.c. Gelatin	Bacteria per c.c. Agar	B. coli found in: 10 c.c.	1 c.c.	0.1 c.c.
7	4/10	7th & Scott	120	1,130	200	+	-	-
14	4/11	4th & Court	260	5,600	1,010	+	+	-
15	4/11	7th & Greenup	310	—	730	+	+	-
24	4/12	4th & Court	260	4,420	660	+	+	+
32	4/13	4th & Court	110	1,030	200	+	+	-
38	4/14	4th & Court	220	3,530	270	+	+	-
43	4/16	4th & Court	400	8,000	680	+	+	-
49	4/17	4th & Scott	100	3,700	223	+	+	-
50	4/17	4th & Court	100	8,400	230	+	-	-
55	4/18	4th & Court	270	32,200	795	+	-	-
60	4/19	4th & Court	170	1,300	680	+	+	-
64	4/20	4th & Court	380	--	1,080	+	-	-
68	4/21	4th & Court	260	--	550	+	-	-

Analyses of Newport Water Supply

made by

U. S. Public Health Service.

Sample No.	Date 1923	Source from tap at:	Turbidity	Bacteria per c.c.		B.coli found in:		
				Gelatin	Agar	10 c.c.	1 c.c.	0.1 c.c.
	4/6	126 E.Front		780	230	+	+	+
A	4/9	126 E.Front		1,520	410	+	+	+
6	4/10	126 E.Front	100	1,970	405	+	+	-
12	4/11	9th & Wash	100	1,640	400	+	+	-
13	4/11	126 E.Front	---	730	210	+	+	-
18	4/12	126 E.Front	170	8,400	400	+	+	-
19	4/12	3d & Saratoga	120	6,620	270	+	+	-
26	4/13	126 E.Front	100	2,310	240	+	+	-
27	4/13	3d & Saratoga	65	1,130	100	+	+	-
36	4/14	126 E.Front	70	1,980	220	+	-	-
41	4/16	126 E.Front	210	9,500	870	+	+	-
47	4/17	126 E.Front	250	62,000	6,950	+	+	+
53	4/18	126 E.Front	160	52,400	560	+	+	+
58	4/19	126 E.Front	300	48,200	1,070	+	+	-
62	4/20	126 E.Front	210	33,000	610	+	-	-
66	4/21	126 E.Front	200	----	340	+	-	-

Analyses of Fort Thomas Water Supply

made by

U. S. Public Health Service.

Sample No.	Date 1923	Source from tap at:	Turbidity	Bacteria per c.c.		B.coli found in:		
				Gelatin	Agar	10 c.c.	1 c.c.	0.1 c.c.
4	4/10	Pump room	220	540	350	+	+	-
5	4/10	Drug store	180	580	270	+	+	-
10	4/11	Pump room	200	470	600	+	+	-
11	4/11	Drug store	260	610	600	+	+	-
23	4/12	Pump room	190	360	370	+	-	-
30	4/12	Drug store	130	770	280	-	-	-
31	4/13	Pump room	95	210	140	-	-	-
38	4/13	Drug store	75	190	140	-	-	-
37	4/14	Drug store	75	235	102	+	+	-
42	4/16	Drug store	80	195	115	+	-	-
48	4/17	Drug store	110	360	132	+	+	-
54	4/18	Drug store	100	540	320	+	-	-
59	4/19	Drug store	170	800	530	+	-	-
63	4/20	Drug store	140	1,400	320	+	-	-
67	4/21	Drug store	130	900	395	+	-	-

Cross-connection between the Covington and Newport Supplies.

The supplies of the two cities are connected so that in the case of an emergency one of them can furnish the water to both. On February 9, 1923, at 1 A.M., due to a shortage of water in Covington, the supply for Newport was turned into the Covington mains. The supplying of Covington by Newport continued until 2 P.M., February 10.

On March 30, 1923, at 3:25 P.M. the supply of Covington was turned into the Newport mains and Covington has furnished water to both cities since that time.

Defects of the Newport Water Supply.

The drainage area tributary to the storage reservoir is steep, and inhabited to a considerable extent. The reservoirs, not being water-tight, permit the inflow of polluted seepage water from unsewered houses on the drainage area. During periods of heavy rains the run-off from the surrounding territory frequently enters the water reservoir as shown by the condition of the banks at the upper end of the south basin.

It is believed that the arrangement for coagulating the water is not effective in its present form. No attempt is made to sterilize the water before it is delivered to the consumers, although the need of such treatment has been called to the attention of the City Commissioners by the State Board of Health on two or three occasions during the past three years.

The cutting off of the Newport supply.

Due to the reservoirs of the Newport supply being empty, it was possible to make an examination of them, and their condition was such that the State Board of Health, in an order dated April 7, 1923, declared that the reservoirs were a nuisance, a source of filth and cause of sickness, and ordered that no water be distributed from these reservoirs for domestic purposes until the conditions were corrected. The grounds upon which this order was based were that the reservoirs were lined with rip-rap which permitted the seepage of sewage at a number of points. The section of Fort Thomas above the reservoirs is not sewered, and cesspools and septic tanks discharge into ditches which flow towards the reservoirs.

Defects of the Covington Public Water Supply.

No adequate means is provided for supplying pure water from this system. When for various reasons storage is not available, raw Ohio River water with its burden of turbidity must be used, treated only with chlorine, which under such circumstances is an inadequate safeguard. It was found that the point of application of the chlorine is such that it is impossible to secure a thorough mixing with the water and that probably the Fort Thomas supply was receiving a disproportionate amount of chlorine, to the detriment of the Covington

supply. Although the Covington reservoirs are concrete-lined, the watershed tributary to these basins is quite densely populated and this condition is a potential if not an actual source of danger. A rigid continuous control of this population should be strictly enforced.

Features responsible for the epidemic of Typhoid Fever.

The Ohio River was at a high stage during the first half of February due to heavy rains on the watershed, causing, as such conditions do, an increased turbidity and higher concentration of pollution of the river water. Owing to difficulty in operation of the pumps, the storage period in the reservoirs was considerably decreased, resulting in the delivery of a highly turbid water to the consumers as well as a water more difficult to treat with chlorine. The small amount of chlorine added (approximately 0.2 part per million) was insufficient to overcome the increased absorption of this chemical by the high organic content of the water, and this in turn permitted the bacteria to pass unharmed through the mains. Lack of laboratory control of the treatment process and of the quality of water being delivered to the consumers, enabled these conditions to continue undetected, and the typhoid fever cases and deaths in Covington were the result. The same identical chain of circumstances is responsible for the cases and deaths

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in Newport, with the exception of the fact that Newport does not even attempt to sterilize its water supply by chlorine and so the channel of infection through that system is even less obstructed.

SUMMARY AND CONCLUSIONS.

1. The epidemic of typhoid fever in Covington, Newport and adjacent territory was caused by the polluted water delivered to their consumers by the public water supply systems of those cities.

2. The present treatment of the Covington supply, consisting of storage and chlorination as now provided, is inadequate, and cannot be relied upon to produce a safe effluent at all times.

3. Insufficient chlorine has been used to effect even partial sterilization during periods of high turbidity when the organic content of the raw water is excessive.

4. The point of application of chlorine gas to the Covington supply is so located that a proper mixture of the sterilizing agent with the water is not insured before the Fort Thomas supply is withdrawn from the supply main.

5. The crude method of application of chemicals for the purpose of coagulation of the Newport supply is not carefully regulated and is ineffective.

6. Raw Ohio River water is absolutely unfit for human consumption without proper purification; facilities for such purification are not now existent in Covington, Newport or Fort Thomas.

7. These cities must expect recurrent epidemics of intestinal, water-borne diseases such as typhoid fever, dysentery and diarrhea, until all of the water supplied to their citizens is properly purified by a modern, thoroughly equipped treatment plant operated under the constant supervision of trained personnel.

RECOMMENDATIONS.

Recommendations for temporary relief have been made heretofore, relating principally to changes in methods of the application of chlorine to secure the highest practicable efficiency from this form of treatment. For permanent relief, additional recommendations are submitted:

1. That competent engineering advice be obtained and followed relative to the best methods of securing adequate facilities for the efficient purification of all water supplied by both municipalities to their consumers.

2. That frequent bacteriological analyses be made, by a competent bacteriologist, of samples of water taken from various points in the distribution system, to determine the quality of

the water being supplied to consumers, as well as to determine the amount of chlorine to be added to the end that as good an effluent as it is possible to obtain be produced by this means.

3. That connections to sewers be promptly and strictly enforced at all places where sewers are available, and that all pit and surface privies be eliminated in both cities, in order to reduce the danger of fly transmission of typhoid during the summer months.

4. That a rigid and systematic control be exercised over the disposal of excreta discharged on the drainage areas of the storage reservoirs.

Respectfully submitted.

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